CHLAMYDOMONAS AND ITS EFFECT ON WATER SUPPLIES.

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WITH PLATE VII.

It is now a well known fact that most of the unpleasant tastes and odors that affect public water supplies are caused by microscopic organisms, and it is somewhat surprising to find that, amidst the host of existing forms, the troublesome organisms are limited to about twenty-five genera. The following table shows the important odor-producing organisms, together with the odors that they impart to drinking water:

Group	Organism	Natural Odor
Aromatic Odor:	Diatomaceae—	
	Asterionella,	Aromatic-geranium-fishy.
	Cyclotella,	Faintly aromatic.
	Diatoma,	Faintly aromatic.
	Meridion,	Aromatic.
	Tabellaria,	Aromatic.
	Protozoa—	
	Cryptomonas,	Candied violets.
	Mallomonas,	Aromatic-violets-fishy.
	Chlamydomonas,	Aromatic-fishy-unpleasant.
Grassy Odor:	Cyanophyceae—	
	Anabaena,	Grassy and moldy-green corn-nasturtiums-etc.
	Rivularia,	Grassy and moldy.
	Clathrocystis,	Grassy and sweetish.
	Coelosphaerium,	Grassy and sweetish.
	Aphanizomenon,	Grassy.
Fishy Odor:	Chlorophyceae—	
	Volvox,	Fishy.
	Eudorina,	Faintly fishy.
	Pandorina,	Faintly fishy.
	Dictyosphaerium,	Faintly fishy.

	Protozoa—	
	Uroglena,	Fishy and oily.
	Synura,	Ripe cucumbers - bitter and spicy taste.
	Dinobryon,	Fishy, like rockweed.
	Bursaria,	Irish moss-salt marsh-fishy.
	Peridinium,	Fishy, like clam-shells.
	Glenodinium,	Fishy.
Vegetable Odor:	Diatomaceae—	
	Synedra,	Indistinct vegetable odor.
	Melosira and others,	Indistinct vegetable odor.

Recently it has been found that *Chlamydomonas* is an odor-producing organism. Attention was first called to this by Hollis and Parker,* who found the organism in Spot Pond, Stoneham, Mass.

This pond covered nearly three hundred acres and had a maximum depth of thirty-seven feet, but about one-fifth of the pond had a depth of less than six feet. The bottom of the pond was covered with thick deposits of mud, and the water that entered the pond came partly from a swampy region. These conditions no longer exist, as the pond has been recently acquired by the Metropolitan Water Board, and is being improved and developed as a storage reservoir.

Chlamydomonas was first observed in Spot Pond in August, 1898, but its maximum growth did not occur till November. After Nov. 21st it decreased rapidly, but lingered in small numbers through the following winter and spring. At the time of its maximum growth it was present as follows:

	Number per cc.	Standard Units per cc.†
Surface,	628	156
Mid-depth,	682	171
Bottom,	532	133

It was found that "moderate numbers gave a somewhat unpleasant sweetish and oily taste and odor, and the oily and unpleasant character became more pronounced as the number of

* *Chlamydomonas* in Spot Pond, by Dr. F. S. Hollis and Horatio N. Parker, Journal of the New England Water Works Association, Vol. IV., No. 1, Sept., 1899.

† One Standard Unit equals 400 square microns.

organisms increased, becoming fishy and even offensive when high numbers were present."

The writer has had recently the opportunity of corroborating the testimony of Hollis and Parker as to the odor-producing qualities of *Chlamydomonas*, and of noting the occurrence of the organism under conditions very different from those existing in Spot Pond.

The 26th ward of Brooklyn, N. Y., is supplied with water from driven wells, usually pumped directly into the pipes. A reservoir is connected with the distribution system, and is drawn upon whenever the consumption exceeds the amount of water pumped. For the greater part of the time, however, the water in the reservoir is stagnant. The reservoir has a capacity of about five million gallons, and the depth at high water is about eighteen feet. The bottom is of clay, and the slopes are cemented.

On Nov. 16, 1899, the water in this reservoir contained 5120 *Chlamydomonas* per cubic centimeter (equal to 1200 Standard Units), or about eight times as many as were found in Spot Pond. It had a decided green color as seen from above, and a distinct aromatic, almost fishy odor. The odor was much intensified by heating the sample, and after standing a few days, odors of decomposition could be observed. The temperature of the water on Nov. 16th was 8.5° C. On Nov. 21st, the water contained 4248 *Chlamydomonas* per cc.; on the 27th, 1328; and on Dec. 6th, 608. As the organisms decreased the odor became correspondingly less in intensity, though it still retained its characteristic aromatic and unpleasant qualities.

The comparison of the growth of *Chlamydomonas* in Brooklyn with that in Spot Pond is interesting because of the very different character of the water in the two places. This difference is well shown by the chemical analysis on the next page.

It will be observed that while the amount of organic matter is much greater in the Spot Pond water, the nitrogen available as plant food is far greater in the water from the driven wells. *Chlamydomonas* is, no doubt, largely influenced in its food supply by the amount of nitrates present.

	Spot Pond (Average for 1897)	Driven Wells of Long Island Water Supply Co. (Nov. 16, 1899)
	In Parts per Million	
Color, (Platinum-cobalt Standard)	0.370	0.000
Albuminoid ammonia	0.273	0.004
Free ammonia	0.021	0.000
Nitrites	0.001	0.003
Nitrates	0.030	9.000
Total residue on evaporation	51.100	279.500
Hardness	20.000	166.000
Chlorine	5.700	28.000

The occurrence of *Chlamydomonas* under conditions differing so widely as in the two illustrations would imply that the organism may develop in almost any pond or reservoir. The early records show that it is a very widely distributed organism, but, with a few exceptions, it has thus far escaped the notice of those biologists who are studying water supplies. There are several reasons for this. The organisms are seldom present in water supplies in numbers sufficient to attract attention by their odor; they are much smaller than most of the common organisms, and the powers of the microscope that are ordinarily used in water examination fail to bring them out with distinctness; and their small size permits many of them to pass through the sand of the Sedgwick-Rafter filter unless an extremely fine sand is used.

The maximum growths of *Chlamydomonas* in Spot Pond and in Brooklyn both occurred during the month of November, but the organism may be found at all seasons of the year. It is frequently present in the reservoirs of the Brooklyn Water Supply during May and June.

Several species of *Chlamydomonas* have been described, but they are of doubtful value. Hollis and Parker stated that the forms observed by them resembled *Ch. albo-viridis* St., but that in some of their phases they resembled several of the nine

forms described by Goroshankin.* The forms observed by the writer have agreed in most cases with the figures of *Ch. pulvisculus* Ehrbg. as given by Bütschli. The adult individuals were almost spherical and averaged about 12μ in diameter. The flagella were generally two in number and about twice the length of the body. The cell contents consisted of a single chromatophore, situated near the base of the cell, or cleft and extending forwards; a contractile vacuole near the base of the flagella; a nucleus almost in the center of the cell; certain minute particles said to be starch granules; and oil-globules. As a rule, no eye-spot was visible. The cell was usually surrounded by a thin lorica, but several forms were observed where the entire cell was embedded in a spherical mass of jelly about 30μ in diameter, similar to that surrounding *Haematococcus* Agardh (*Chlamydococcus* A. Braun). In these cases the cells were flask-shaped, the small end terminating at the surface of the jelly and the flagella extending out through a depression in the surface. The length of the flask-shaped cells was 18μ, and the diameter was 12μ. Division of the cells took place, and groups of four, eight, sixteen and thirty-two cells were observed. In most cases the daughter-cells were provided with long hair-like processes, some of them having a length of over 100μ. The daughter-cells were grouped in scattered colonies surrounded by a common sheath, or in compact botryoidal clusters without sheath, and having hair-like processes radially disposed like the pseudopodia on *Actinophrys*.

During the occurrence of *Chlamydomonas* in the reservoir of the Long Island Water Supply, the water at first contained no other organisms except a few *Synedra ulna*, but later rotifers of various kinds became abundant. On Dec. 6th the water contained the following:

	Approximate number per litre
Branchionus pala Ehrbg.....	800
Synchaeta pectinata Ehrbg	400
Anuraea cochlearis Gosse.....	400
Notommata aurita Ehrbg.....	2400

As the number of rotifers increased the *Chlamydomonas* became less abundant.

* Proceedings of the Society of Natural History of Moscow, 1891.

PLATE VII.

EXPLANATION OF FIGURES.

Figs. 1-4. *Chlamydomonas* Ehrbg. After Hollis and Parker.
Figs. 5-6. *Chlamydomonas pulvisculus* Ehrbg. Typical forms.
Figs. 7-9. " " " Divisional forms.
Fig. 10. " " " With gelatinous coating.
Fig. 11. *Haematococcus lacustris.* After Bütschli.
Fig. 12. *Chlamydomonas albo-viridis* St. After Bütschli.

PLATE VII